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REVIEW OF THE IMPLEMENTATION OF COMMITMENTS AND OF OTHER PROVISIONS OF THE CONVENTION

RESEARCH AND SYSTEMATIC OBSERVATION

Report on the development of the observational networks of the climate system

Note by the secretariat

1. By its decision 8/CP.3, the Conference of the Parties (COP) at its third session requested the Subsidiary Body for Scientific and Technological Advice (SBSTA), with the assistance of the secretariat and in consultation with the Intergovernmental Panel on Climate Change (IPCC), to consider the adequacy of observational systems and to report on its conclusions to the COP at its fourth session (FCCC/CP/1997/7/Add.1). The observational networks referred to in the decision include the Global Climate Observing System (GCOS), the Global Ocean Observing System (GOOS) and the Global Terrestrial Observing System (GTOS).

2. At its eighth session, the SBSTA considered a report by the World Meteorological Organization (WMO). The report noted that the organizations participating in the Climate Agenda would prepare a comprehensive report on the adequacy of the global observing systems as requested by decision 8/CP3. The SBSTA recognized the deteriorating situation of the observational networks of the climate system and urged Parties to give high priority to

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* Including the ninth sessions of the Subsidiary Body for Scientific and Technological Advice and the Subsidiary Body for Implementation.

reversing this decline and to introducing improvements (FCCC/SBSTA/1998/6). The SBSTA further invited the organizations participating in the Climate Agenda to complete the comprehensive report and make it available for consideration at its ninth session.

3. Further to this request, the GCOS Secretariat in WMO on behalf of the organizations participating in the Climate Agenda, has coordinated the preparation of a comprehensive report on the adequacy of the global observing systems (FCCC/CP/1998/MISC.2). A summary of the comprehensive report is reproduced without formal editing in the attached annex.

4. The SBSTA may wish to consider the information provided in the annex, to express appreciation to the organizations participating in the Climate Agenda for the preparation of the report and to consider, and as appropriate, endorse some or all of the recommendations contained therein and to report to COP 4 accordingly.

5. It may also wish to invite the organizations participating in the Climate Agenda to keep the SBSTA informed of developments regarding observational networks, particularly difficulties encountered, *inter alia*, with respect to the needs of developing countries.

Annex

REPORT ON THE ADEQUACY OF THE GLOBAL OBSERVING SYSTEMS

Executive Summary

INTRODUCTION

In recent years the prospect that the global climate could change as a result of human influence has generated widespread concern. A concerted global response has developed as a result of this potential for human-induced climate change. A Framework Convention on Climate Change (FCCC) has been ratified and come into force.

The emissions of carbon dioxide and other so-called "greenhouse gases" into the atmosphere are capable of modifying the global radiation balance giving rise to global climate effects. To establish that such anthropogenic influence is occurring requires that the signal be detected against the background of natural variability that is characteristic of the climate system. To provide scientifically credible advice on the future evolution of the climate and to provide information to guide mitigation and adaptation strategies to address potential impacts of climate change requires a continuing supply of selected observational information.

The third session of the Conference of the Parties (COP) requested the Subsidiary Body for Scientific and Technological Advice (SBSTA), in consultation with the Intergovernmental Panel on Climate Change (IPCC), to consider the adequacy of the relevant global observing systems and to report on its conclusions to the COP at its fourth session (Decision 8/CP.3).

The operation of the relevant observing systems is coordinated and facilitated by a number of international / intergovernmental organizations. These and other agencies[1] have prepared "The Climate Agenda" outlining a strategy for international cooperation in climate research, services, impacts, and more specifically for observations. The Global Climate Observing System (GCOS), which includes the climate aspects of the Global Ocean Observing System (GOOS), the Global Terrestrial Observing System (GTOS), and other observing systems, provides the focus for climate-related observations. These observations are collected through cooperative efforts among relevant national and international organizations. Because of its specific mandate to address observations for climate, GCOS has taken the lead in providing assistance to SBSTA in the preparation of this report to the fourth session of the COP.

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[1] The organizations that sponsor the Climate Agenda are the Food and Agriculture Organization (FAO), the United Nations Educational, Scientific and Cultural Organization (UNESCO) and its Intergovernmental Oceanographic Commission (IOC), the United Nations Environment Programme (UNEP), the World Health Organization (WHO), the World Meteorological Organization (WMO), and the International Council for Science (ICSU).

This report has three purposes:

- To identify the essential observations needed to support the FCCC;
- To assess the adequacy of existing and planned observing systems to meet the needs; and
- To make specific recommendations for improvements.

The report concludes that many of the observational requirements are generally known and documented and that many of the observing components are in place, but need augmentations and enhancements to serve climate purposes. Fortunately many of the techniques needed to obtain the measurements are currently available and cost-effective and an appropriate infrastructure has been identified to facilitate the climate-related observations.

What is urgently needed now is a commitment by nations to provide global coverage for the key variables, to halt and reverse the degradation of existing observing systems, and to exchange information more effectively. Specific improvements are needed in atmospheric, oceanic, and terrestrial systems. It is recommended that each Party should undertake programs of systematic observations in accordance with national plans which they should develop in concert with the overall strategy for global climate observations. A positive response to this challenge would significantly advance the implementation of an effective observing system for climate and support the objectives of the FCCC.

OBSERVING THE EARTH'S CLIMATE

During the past few decades the international scientific community has sought to understand the Earth's climate, to determine its inherent variability, and to predict and assess climate change arising from anthropogenic influences. These studies have mostly been based on analyses and models using available historical data. Such data have often been obtained from observing networks established for purposes other than climate. Although many of the existing observing networks satisfactorily meet their specific objectives (e.g., weather forecasting, aviation and marine operations, or research programs), the scientific community engaged in climate research, and in particular, the IPCC, have identified deficiencies in the observing networks which limit their utility for climate purposes.

The GCOS and others have undertaken a detailed analysis of the observational requirements for climate and the capability of existing and planned observing networks to meet them. The analysis determined that many national, regional, and global programs currently provide significant observational information useful for climate. These programs should be acknowledged and encouraged to continue their efforts.

However, when measured against the specific requirements for climate, the observing networks display several types of deficiencies and inadequacies. For example:

- Satisfactory global coverage for many of the essential climate variables has not been achieved. Meteorological networks have large gaps over several continents and much of the ocean. Recent declines in the absolute numbers of surface observations have been documented. These gaps in global coverage seriously impact climate assessment and modeling efforts.
- Regional coverage is not adequate in many areas. Surface and upper-atmosphere observations from large parts of Africa, Asia, and South America are not available. Ironically, these gaps in regional coverage are typically most serious in regions where impacts of climate change are expected to be most severe.
- Observations of selected variables often do not have adequate accuracy or precision to be reliably used as indicators of climate change. Changes in station siting and techniques or methods of observation have often been made with little consideration of the impact on climate records. Resulting instrumental drifts and biases are difficult if not impossible to remove after the fact.
- Key data sets, although collected, are often not effectively exchanged. This problem has many sources and is currently being addressed at various levels. However, for climate, the result is that potentially valuable global or regional data sets are often unavailable to the user communities.

If not rectified, these and similar deficiencies will seriously impact the ability of the scientific community to provide essential information to guide assessments of future climate change and in particular to support the work of the Convention.

GOALS, REQUIREMENTS, AND IMPLEMENTATION

Goals

There are several interrelated goals that observational programs must meet to provide an effective foundation for climate studies and assessments in general, and in support of specific issues facing the FCCC. These are to:

1. Observe and characterize the current climate, including its variability and associated extreme events;
2. Obtain information useful to detect climate change, determine the rate of change and assist in attributing the causes of change;
3. Provide observations to determine climate forcing resulting from changing concentrations of greenhouse gases and other anthropogenic causes;
4. Provide observations to validate models and assist in prediction of the future climate;
5. Contribute observations to understand and quantify impacts of climate change on human activities and natural systems.

Requirements

To observe and characterize climate, it must be recognized that the climate system is fundamentally global and involves interactions among all components (land, sea, ice and air). Importance is therefore attached to comprehensive, global data sets to delineate the important signals of climate variability and to minimize the uncertainty. Data with long uninterrupted records warrant special consideration. Since the atmosphere is central to climate, it is essential to characterize the three-dimensional state of the atmosphere and the meteorological conditions at the Earth's surface. Global surface pressure and temperature fields of high quality and temporal and spatial consistency are essential. Sea surface conditions, including sea ice are important. The ocean is an integrator of variability, suppressing and weakening high-frequency fluctuations in favor of the slowly varying climate signals. The ocean requirements include annual fields of global sea level change, time series stations with long, high-quality records, a limited number of repeated, high-quality full depth trans-oceanic sections, and enhanced sampling of the upper ocean. Measurements of the carbon cycle in the ocean are needed, but present a severe challenge. Land surface characterization requires information on the hydrological cycle variables including the cryosphere.

Detection and attribution of climate change require the identification of statistically significant changes in climate against a background of natural variability and of causes of such changes, respectively. This demands particular attention be given to the quality and comprehensiveness of the data sets and the methods of processing. Current emphasis on coherent patterns of change (hypothesized versus measured) requires an integrated system of components each functioning in a prescribed manner.

To determine climate forcing due to atmospheric constituents the detailed requirements are a function of the particular constituent. Uncertainty in the quantity and distribution of atmospheric constituents contributes significantly to uncertainty in their effective global warming potential. All elements of radiative exchange, including ozone concentration, must be measured on a long-term, continuing basis. Aerosols have recently been shown to play a key role in the radiative exchange and reliable global estimates are now needed. The use of models to develop predictions based on various greenhouse scenarios is an accepted strategy for climate change assessment. Their uncertainty depends in part on the validity of the model, and that in turn is a strong function of the model assumptions and parameterizations. Comprehensive data sets are required to establish model validity and to test parameterizations. Process studies are extremely important for developing models and improving confidence in their projections. For carbon cycles there is a requirement for better monitoring in all spheres of the climate system - land, ocean and atmosphere.

To understand and quantify impacts of climate change on human activities and natural systems a variety of variables must be systematically observed. Due to the many potential land surface impacts of climate change, and the diversity of products that are of value to user communities, a prioritization of the terrestrial variables has been made. Land cover and use measurements,

hydrological variables, biophysical properties of vegetation, and biogeochemical variables are included. Some observations fall outside the remit of the global observing systems (e.g., incidence of diseases or details of change in biodiversity) so coordination with appropriate groups is being fostered.

Implementation

The responsibility for securing the observations to meet this suite of requirements rests with the various national agencies and programs. To be effective, the observing system components should be collected in accordance with an internationally coordinated strategy. A number of international organizations prepared the Climate Agenda with a major thrust to obtain dedicated observations of the climate system. They identified GCOS as the coordinating program for observations. Several international organizations[2] established the GCOS to develop a comprehensive approach for climate observations. GCOS documented the needs through extensive dialogue with the scientific community, and assessed the current and projected capability of observing systems to meet them through consultation with appropriate programs. Based on the findings, GCOS proposed recommendations through its sponsoring organizations to address critical issues and deficiencies.

The GCOS builds on existing operational and research observing activities through partnerships, recommending new observing components only when necessary. The individual observing components that comprise GCOS are operated by individual nations through commitments to work within the GCOS framework. In many nations, the basis for contributing to GCOS already exists. Commitment to continue and improve the operation of existing networks and to support appropriate augmentations and enhancements is now required. For some nations, participation will require new observational sites or networks. Financial assistance to help some of them participate in undertaking systematic observations and benefit from the resulting efforts needs to be identified.

RECOMMENDATIONS

Based on the analysis of the required observations and assessments of current and future observing systems, feasible and cost-effective recommendations for improvements have been formulated. First, three general recommendations, most effectively addressed by the Parties to the Convention working in concert, are proposed. Second, specific recommendations, perhaps best addressed by individual nations through appropriate national agency activities, focus on particular elements of the observing systems. Implementation of these recommendations should provide current and future generations with the observations and data required to support the evolving needs of the FCCC.

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[2] IOC, UNEP, WMO, and ICSU.

General Recommendations

It is essential that the Parties to the Convention continue to place a high priority on the acquisition of observations to reduce uncertainties and adverse effects of climate change. To be effective, the observations should be collected and exchanged in accordance with an overall strategy. Parties should encourage and support the preparation of specific national plans, based on overall plans formulated by GCOS and its partner programs. The national plans should contain commitments to undertake specific implementation actions.

Parties should allocate necessary financial and human resources to support, independently and collectively, the observing activities of the relevant international organizations. Where the established observing networks are inadequate or absent, the Parties should contribute to their development through appropriate funding mechanisms.

The Parties should request regular reports on the status of the observing system and its implementation. These could be coordinated by the GCOS Secretariat on behalf of the participating programs and with the participation of SBSTA.

For many of the important variables, observations may be underway but the resulting data are often not effectively shared. The FCCC commits Parties to exchange climate data and to develop climate data archives. The Parties should reaffirm their commitment to this principle and in particular support efforts to eliminate barriers which limit the exchange of climate information.

Systematic evaluations of the performance of current observing systems indicate a number of geographical areas are sparsely covered. For example, atmospheric and terrestrial observations are often lacking in large areas of Africa, South America and parts of Asia. To redress these and similar deficiencies, a concerted effort in capacity building must be undertaken. It is one of the tenets of the FCCC and the Kyoto Protocol that the development and strengthening of endogenous capacities and capabilities be promoted. The parties should reaffirm their support of capacity building through appropriate programs of the international agencies and other mechanisms as appropriate.

Recommendation 1

Each Party should undertake programs of systematic observations including the preparation of specific national plans, based on the overall plans formulated by GCOS and its partner programs. The national plans should contain commitments to undertake specific implementation actions and be tabled and reviewed at regular intervals at COP sessions.

Recommendation 2

Parties should exchange, with other nations and with appropriate international organizations, those data required to meet climate objectives and the needs of the FCCC. They should take active steps to eliminate any internal barriers to such exchange.

Recommendation 3

Parties should actively support capacity development to enable countries to collect and utilize observations to meet local and regional needs. The capacity building programs of appropriate international organizations could assist countries to acquire and use climate information. If necessary, Parties should reconsider the priorities of funding mechanisms which support the FCCC.

Specific Recommendations

Due to the complexity of the climate issue, the observing systems are composed of a large number of individual components which must be integrated into an effective composite system. This requires adherence to a set of guiding principles which ensure the integrity of the long-term networks for the various components. The performance of the networks should be continuously monitored to ensure quality control. Space-based observations provide a particularly significant contribution to the global observing systems but also pose specific issues which are being addressed in cooperation with the space agencies. In particular, an Integrated Global Observing Strategy (IGOS) is now being developed by the international organizations and the space agencies to foster coordination, to avoid duplications and gaps, and to provide a mechanism for long-term continuity of the critical space-based climate measurements.

For convenience, the global observing systems may be discussed in terms of the three major components: atmospheric, oceanic, and terrestrial. Each of them is in markedly different stages of development. The following discussion of the systems and the specific recommendations are illustrative. For details, the Background Report should be consulted.

1. Atmospheric Observations

The atmospheric component of the climate observing system is the most developed. This is due to the long heritage of national cooperation to obtain and exchange those observations required for weather forecasting. Current characterizations of the dynamic and thermodynamic aspects of the climate system are provided through the World Weather Watch (WWW), a composite observing system including meteorological satellites, as well as global surface and upper-air measurement systems.

While the WWW is effective for many purposes, difficulties persist in providing truly reliable global coverage and in maintaining the standards needed for climate applications. Significant

regions of the globe are inadequately observed and many areas have experienced declines in the number and quality of the observations. For upper-air observations, the number of observations has decreased somewhat, but many fewer regions of the globe, particularly in the tropics and Southern Hemisphere, have regular coverage.

To meet specific climate objectives, GCOS selected elements of the WWW to form the basis of a climate network. The GCOS Upper-Air Network (GUAN), consisting of about 160 stations, and the GCOS Surface Network (GSN), consisting of about 1000 stations, were designed to form the basis of a high-quality global-scale climate network. Despite national agreements to maintain these networks, there are deficiencies in their current operation. Evaluations indicate that over 35% of the GUAN stations failed to fully provide the specified observations in the last quarter of 1997. For the GSN the global performance is under review, but many regions of the world are seen to be experiencing major gaps in coverage. In Africa, for example, 45 of the five-degree square grids failed to report one station report per month in 1997. Difficulties arise in parts of Asia as well.

The Global Atmosphere Watch (GAW) currently provides baseline global and regional observations of well-mixed atmospheric constituents including greenhouse gases in support of GCOS. In conjunction with satellite observations, it also provides information on ozone concentration, although the network is not adequate to document the distribution in the troposphere and in the Southern Hemisphere stratosphere. For example in South America there is only one CO_2 station and none for CH_4, N_2O or CFCs. In Africa only two stations systematically observe CO_2 and in the former Soviet Union there is only one.

Recommendation 4

Countries should support national meteorological observing systems and particularly ensure that the stations identified as elements of the GCOS networks based on the WWW and GAW are fully operational and that best practices are maintained. Support should be provided to assist countries as needed. The number of stations in the observing networks for atmospheric constituents including ozone, and aerosols when formulated, should be increased. Satellite missions to observe and quantify atmospheric constituents should continue.

2. Oceanic Observations

The oceanic component of the climate observing system is in a rapid state of development. Oceanographic research activities over the past decades (e.g., the Tropical Ocean Global Atmosphere (TOGA) and World Ocean Circulation Experiment (WOCE) of the World Climate Research Programme (WCRP)) have identified and provided scientific justification for the ocean parameters that are critical for the climate system. These key elements include sea level, sea surface and upper ocean temperature and salinity, budgets and fluxes of heat, momentum, water and carbon, and sea ice. Particular emphasis should be given to obtain information from the data sparse areas such as the southern oceans; ice-covered regions and the ocean interior, all currently

very poorly sampled. The principal concern is that currently a major fraction of the essential measurements come from research activities and may lack a long-term commitment. Few countries have appropriate operational infrastructure, so long-term commitments are uncertain.

To provide the ocean component of GCOS, GOOS, an operational ocean observing system, is being developed. The proposed system would include contributions from the Global Sea-Level Observing System (GLOSS) and the Integrated Global Ocean System Services System (IGOSS). The climate elements would include sea level, surface marine, and full ocean depth components, each utilizing a balanced mix of techniques, including satellites, to overcome severe ocean sampling difficulties.

Specific efforts are required to maintain the sea level and surface marine networks. After many years, the GLOSS network receives observations from about 75% of the desired sites. Sampling from volunteer observing ships has provided surface and upper ocean observations, but coverage is limited. Currently about 80% of the recommended samples are collected. Increasing numbers of surface drifting buoys are being deployed through regional consortia, but efforts are still needed to achieve the recommended global coverage. Despite efforts to enhance regional sampling, vast areas of the Southern Hemisphere oceans remain unsampled.

To calibrate ocean fluxes, several representative reference stations should be established. A minimal number have been proposed but commitments to implement them have not been received to date. Repeat oceanic profiles need to be undertaken to provide information on climate changes in the ocean. During WOCE, many repeat sections were undertaken, but no firm commitments exist for their continuation.

Recommendation 5

Countries should actively support national oceanic observing systems and particularly ensure that the elements of the GCOS and GOOS networks in support of ocean climate observations are implemented to the degree possible. Support should be provided to increase the number of surface observations, particularly in remote locations, and to establish and maintain reference stations and repeat sections. Current satellite missions to observe sea surface elevation, wind stress, and temperatures should be continued.

3. Terrestrial Observations

The terrestrial observing system component is much less mature. While significant effort has been made in recent years to establish the observational networks that are required to characterize the terrestrial component of the climate system, much research and development remains to be done. Current programs of WCRP and the International Geosphere-Biosphere Programme (IGBP) are providing guidance regarding the priorities to be assigned to the terrestrial variables. The following key elements of land surface processes and land use have been identified: ecosystem state; carbon and other biogeochemical cycles; and the hydrosphere

and cryosphere. Particular emphasis is needed to address the complete range of hydrological, cryospheric, and water cycle related variables (precipitation, evaporation, runoff, storage; soil moisture; snow and ice).

Cooperative efforts are currently under development with the GTOS and through various research and operational programs to establish terrestrial networks. The resulting networks rely on effective utilization of observations from national and international programs that were established principally for non-climate purposes, but suitably modified, could contribute significantly to meet climate needs. The WMO Hydrology and Water Resources program, the Global Runoff Data Center (GRDC), the World Hydrological Cycle Observing System, and the World Glacier Monitoring Service provide notable contributions for hydrological variables. A number of national and international ecosystem networks are coordinating their climate-related observing activities in support of GCOS and GTOS.

There are however many examples of recent declines in observations. Provision of data to the GRDC following an initial exchange of data has diminished substantially, such that reports delivered for 1990 were less than half of those for the early 1980's. Many glacier mass balance survey programs have been discontinued. The coverage of data from high resolution optical satellites, vital for monitoring anthropogenic land cover change including deforestation, was much worse globally in the early 1990's than in the early 1970's, due largely to changes in acquisition strategies. Changes of the overpass times of polar-orbiting meteorological satellites have also led to the deterioration of the long term terrestrial climate record.

Considerable effort will be required to create long-term operational systems, which can provide required global information on many terrestrial variables including land use, fires, glaciers and several other hydrological variables.

Recommendation 6

Countries should actively support national terrestrial networks and in particular the various observational programs to collect, exchange and preserve terrestrial variables according to GCOS and GTOS climate priorities. Specific support is required to secure and distribute relevant hydrosphere and cryosphere observations. Ecosystem networks addressing climate impact should be coordinated to provide global and regional databases. There is a particular need to encourage the transition from research to operational status of many of the terrestrial networks. Strong encouragement and financial support, if appropriate, should be given to developing countries to enable them to collect observations in support of warning systems in connection with extreme events exacerbated by climate change, vulnerability and impacts studies, and national and regional sustainable development efforts.

CONCLUSIONS

There are major deficiencies in the existing observing systems which limit their utility in addressing climate issues and the objectives of the FCCC. Current observing systems were not designed to address climate issues, and moreover they are deteriorating in critical areas. Many of the observations that could be useful are not effectively being shared. To support the goals of the FCCC, stronger commitments to comprehensive sustained observing systems must be made by the Parties to the Convention. Such commitments should be manifest through the national agencies, international organizations, and mechanisms such as the Global Climate Observing System and relevant components of the Global Ocean and Global Terrestrial Observing Systems to ensure an effective long term climate record is developed and secured for the future.

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